EFFECT IN ECONOMY OF AN AUTOMOBILE ENGINE
OF
VARYING THE IGNITER & FUEL VALVE OPENING

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ARMOUR INSTITUTE OF TECHNOLOGY

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The Effect in Economy of an Automobile Engine of Varying the Igniter and Fuel Valve Opening

A THESIS

PRESENTED BY

HARRY G. DEKKER
and
FRANK H. MAYES

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

HAVING COMPLETED THE PRESCRIBED COURSE OF STUDY IN

MECHANICAL ENGINEERING

May 27, 1909

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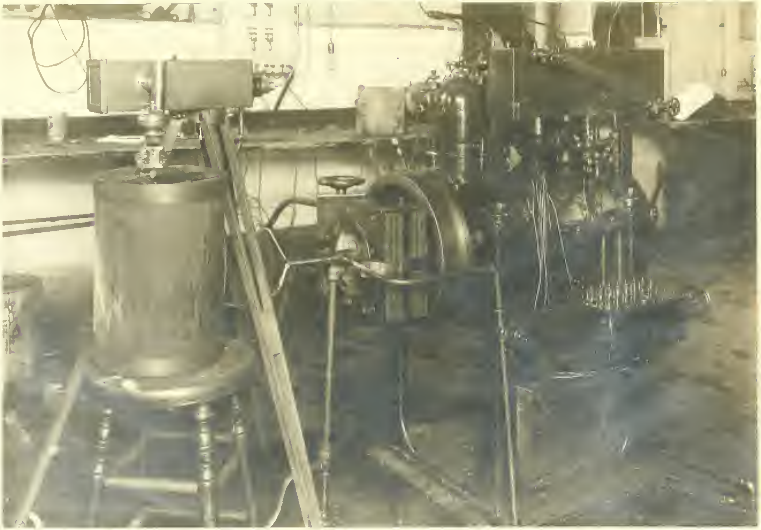


FIG. 3.

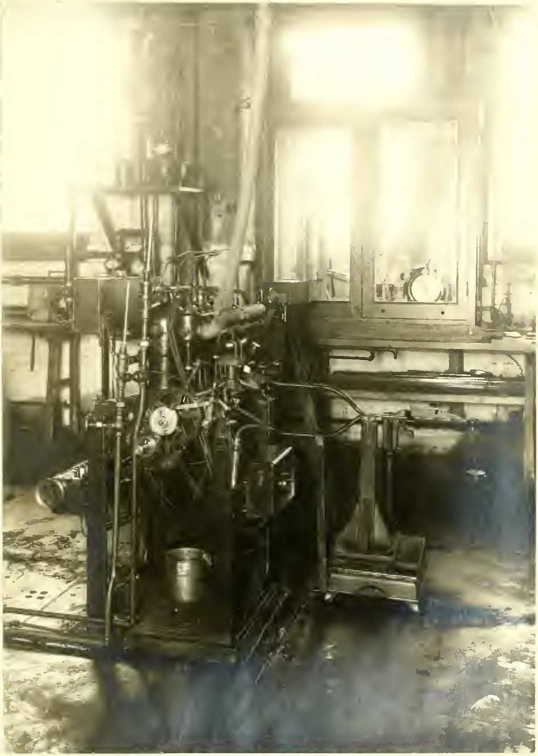


FIG. 4.

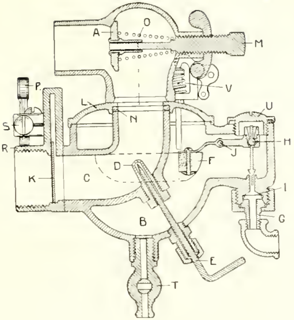
The cylinders are cast in pairs and are 4-3/8" x 4-3/4". The pistons are of the trunk type, each fitted with three cast iron snap rings near the upper end, so as to make a snug fit, preventing the leakage of gases into the crank case.

The valves are of the mushroom type and conically seated. They are operated by cams fitted with tapered pins to the cam shaft. They are forced to their seats by helical springs on the stems. The crank shaft is driven by a one-to-two spiral gear.

CARBURATION

The carburation of the air on its way to the cylinders is accomplished by means of a 1-1/4" Schebler carburetor, model "D" a cut of which is shown on page 6. The bowl contains the intake and float chambers. The float is made of cork, heavily shellaced and is hinged to a small valve, by means of which it controls the supply of gasoline into the float chamber.

MODEL-"D".



A Compensation air valve
B Float chamber
C Mixing chamber
D Spraying nozzle
E Needle valve
F Float
G Reversible union
H Float valve
J Float hinge
K Throttle disk

L Float chamber cover
M Air valve adjusting screw
N Cork gasket
O Air valve spring
P Throttle lever
R Pipe connection
S Throttle stop
T Drain cock
U Float valve cap
V Flushing pin

FIG. 5.

From the float chamber the gasoline is drawn through the spraying nozzle by the air passing it; the mixture then passes into the intake pipe of the engine. The needle valve which regulates the size of the spray is seldom opened more than three-fourths of a turn.

For low speeds the air for the mixture enters through a notch in the seat of the compensating valve. When the speed increases, more air is required since the flow of gasoline is greater, and this additional supply is drawn through the compensating valve which opens against the resistance of a spring. In this manner an approximately uniform mixture of gas and air is secured at various speeds. The gate valve, placed near the pipe connection to the engine, acts as a throttle to the passage of the mixture from the carburetor. The butterfly shutter in the air intake is used only in starting the engine.

By almost closing it a very rich mixture is secured in the cylinders enabling the engine to pick up more easily.

IGNITION

The charge in the cylinders is electrically ignited by the high tension jump spark method. Spark plugs are screwed into the valve chamber and are fitted with two platinum wires one of which is connected to the storage cells through an induction coil, the other being grounded on the engine. Three series-connected storage cells supply low tension current which passes through induction coils to the spark plugs. The induction coil transforms a current of only a few volts into electric energy of higher tension which is necessary to force the spark across the gap under all pressures. A timer is placed in the battery circuit in order to close it at the time required for proper ignition.

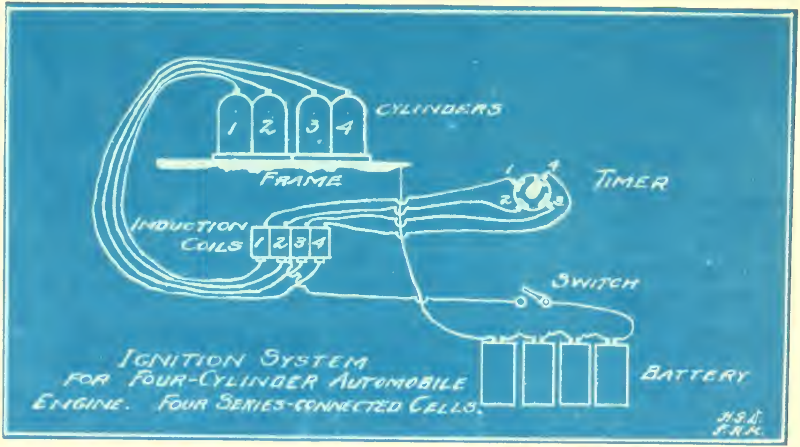

CYLINDERS
1
2
3
4
FRAME
1
4
2
3
TIMER
INDUCTION
COILS
1
2
3
4
SWITCH
BATTERY
IGNITION SYSTEM
FOR FOUR-CYLINDER AUTOMOBILE
ENGINE. FOUR SERIES-CONNECTED CELLS.
H.S.N.
F.R.K.

FIG. 6.

It consists of a rotating and stationary part. The stator has four metal projections which come in contact with the rotor as it revolves. Binding posts for each projection receive the wires leading to the induction coil.

The time of ignition may be varied by a slight movement of the stator about the rotot. This is accomplished by means of a link attached to the stationary part and having a small handle on its other end which fits in a slotted arc fixed to the engine frame. The timer rotates with the cam shaft, its speed of rotation being one half that of the crank shaft.

LUBRICATION

The piston and crank shaft bearings are lubricated by the splash system. Oil is poured into the crank case to such a level that the revolving parts dip into it and splash it up into the cylinder bore, against the piston and upon the rubbing parts.

In order to prevent an excess of lubrication a baffle plate is screwed into the upper part of the crank case.

The two outer main bearings receive their lubrication from two compression grease cups. The remaining rubbing surfaces are oiled by means of an 8-sight, force-feed lubricator, manufactured by the McCord & Co., Chicago.

THE MANOGRAPH

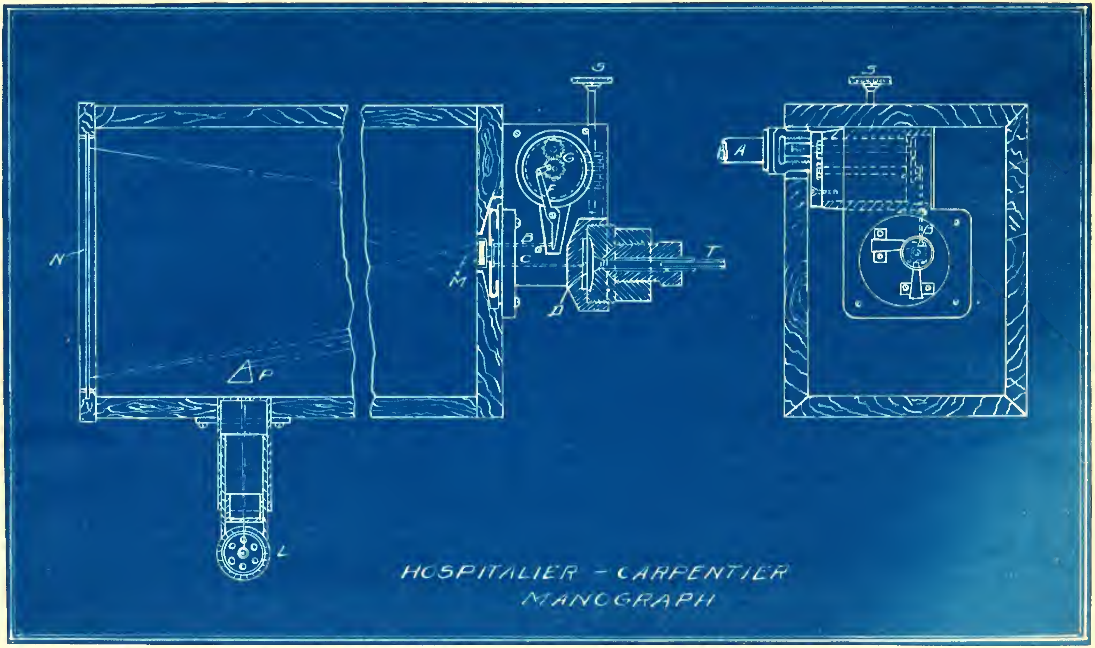
The manograph, by means of which the indicator diagrams were photographed, was manufactured by Hospitalier-Carpentier of Paris. It depends upon a ray of light from an acetylene burner to form an image on a ground glass, or a sensitive plate. The diagrams must be completed in at least one-tenth of a second in order that the eye may see a closed figure. This corresponds to a speed of 1200 R. P. M.

The manograph as connected to a multiple cylinder engine, is shown on page 3. On the 14th page is shown a section of the manograph itself. The box is made of cedar and is light-proof. It is about thirteen and a half inches long, five inches wide, and four inches deep. The acetylene burner is placed at "L" and the light is diffused through the hole "E" to the pin-hole "O", (Fig. 1 - page 15.) The distance from "O" to "E" may be regulated by hand; also the distance "L P" is variable. In order to obtain a more intense light than can be obtained from acetylene, for the purpose of photographing, a piece of magnesia ribbon, three inches long, was inserted into the acetylene flame through the hole "P".

From the pin-hole "O", the ray of light passes to the prism "R", which is of flint and is totally reflecting. A handle is attached to the prism by which it may be

so placed that the ray of light may be focused on the center of the concave mirror "M". The mirror is supported on three points, one of which is stationary ("C-Fig.2) page 15. The piston reducing mechanism is connected to "B" while the pressure diaphram is connected to "A". Since the flexure of the diaphram is not proportional to the pressure in the cylinders, the post "A B" is curved so that the motion of the mirror in a vertical direction is proportional to the pressure, which is communicated to the mirror through the flexible copper tubing "T", and the diaphram "D" which actuates the link "C". The diaphram is of steel and has been calibrated by the makers. (See page 44 for calibration curve). The copper tubing should be as short as practicable, for the extra tubing will materially increase the clearance volume of each cylinder.

The horizontal movement of the mirror is caused by the mechanism shown at "G".



HOSPITALIER - CARPENTIER
MANOGRAPH

FIG. 7.

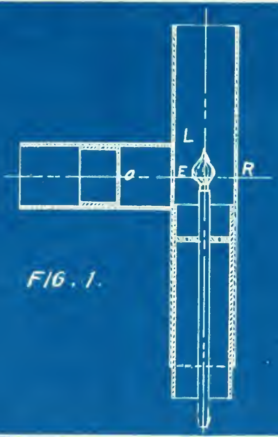


FIG. 1.

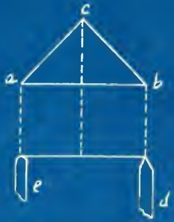


FIG. 2.

A flexible shaft drives the planetary gear "G" which meshes with the pinion to which the crank and the rod "F" are connected. The relative ratio of the crank to the connecting rod is the same as that used on the ordinary auto engine. The pinion "G" is operated through a worm gear by the knurled screw "S". The instrument has been made so that the obliquity of the connecting rod is compensated for, if the explosion end of the card is on the left side. The flexible shaft is connected to the engine shaft by a universal coupling.

Considerable difficulty was at first experienced in getting an image on the photographic plate. Finally, by using magnesia ribbon which was ignited by an acetylene flame and developing the plate by a special method, fairly satisfactory results were obtained. Sigma dry plates, manufactured by the Lumiere N. A. Co., Ltd., were used in Premo plate holders, remodeled to fit the manograph box.

The plates were four inches by five inches and were exposed for fifteen seconds. "Ideal" hydro-methol developing powders were used and were dissolved in twenty-eight ounces of water. This solution was weakened in the proportion of 40 to 1. The plates were allowed to stand in this weak developer over night when six ounces of the normal solution was added. The plates then developed in three to four hours.

METHOD OF PROCEDURE

In each of the five tests made the engine was allowed to run for five or ten minutes previous to taking readings, in order to obtain constant conditions. During the test the following data was recorded at five minute intervals; Prony brake load, speed pressure in the carburetor and temperature of inlet and outlet cooling water. The gasoline draft gauge reading and the weights of cooling water were noted at the beginning and end of each run. Three twenty minute runs of varying fuel valve openings were made for each

of the the first four spark settings given on the timing sheet, page 20. The fifth test was made with only the full opening of the valve.

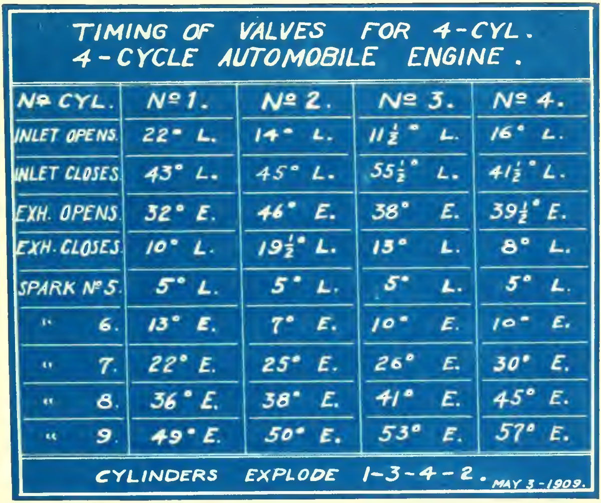
Indicator diagrams were photographed from each cylinder during the full fuel valve opening run for each test, with the exception of #1 in which they were taken when the valve was in mid-position. All the gasoline used was drawn from one barrel and was filtered before being poured into the engine tank. The brake load was held constant throughout each run. The cooling water was discharged into and weighed in a large weighing tank, set upon a platform scale.

DISCUSSION

Considerable preliminary work on the engine was necessary as it only pulled about three horse power in previous tests. The valves were reground, the engine over-hauled, the bearings taken up and the poor spark plugs replaced by others.

The suction at the carburetor was found to be 20 to 24 inches of water; showing that it was too small; where upon a Schebler standard 1-1/4 inch carburetor was installed. After further experimenting, it was decided that the two storage cells of approximately 4.2 volts each, did not give sufficiently high tension spark, and therefore the number was increased to four. The engine then developed its rated horse power. It was found necessary to maintain the voltage of the storage cells nearly constant in order to insure proper ignition. The gasoline tank was calibrated by withdrawing known weights of gasoline from the tank and taking corresponding readings on the draft gauge. The calibration curve is shown on page 50. A setting of the valves which put all of the events about ten degrees earlier was tried, but proved unsatisfactory. The setting as given on page 20, was found preferable because it allowed more time for the burned gases to escape from the cylinders.

The curves on page 33, indicate that the engine runs more economically at or near its rated



TIMING OF VALVES FOR 4-CYL.
4-CYCLE AUTOMOBILE ENGINE.

Nº CYL.	Nº 1.	Nº 2.	Nº 3.	Nº 4.
INLET OPENS.	22° L.	14° L.	11½° L.	16° L.
INLET CLOSES.	43° L.	45° L.	55½° L.	41½° L.
EXH. OPENS.	32° E.	46° E.	38° E.	39½° E.
EXH. CLOSES.	10° L.	19½° L.	15° L.	8° L.
SPARK Nº 5.	5° L.	5° L.	5° L.	5° L.
" 6.	13° E.	7° E.	10° E.	10° E.
" 7.	22° E.	25° E.	26° E.	30° E.
" 8.	36° E.	38° E.	41° E.	45° E.
" 9.	49° E.	50° E.	53° E.	57° E.

CYLINDERS EXPLODE 1-3-4-2. MAY 3-1909.

FIG. 8.

load than at light loads. This is true with any opening of the fuel valve. The rate of decrease of gasoline consumption, however, varies with the opening as shown by the slopes of curves, I, II and III, p.33. Each curve approaches a horizontal line at high loads. The same discussion may be applied to the curves on page 32, in which the economy in pounds of gasoline per brake horsepower per hour is plotted against the spark lead. The slight difference between these two sets is due to the fact that the brake horsepower does not vary directly as the spark lead, but follows the law as shown by the curves on page 31. The thermal efficiency - B. H. P. curves on page 30 indicate that the efficiency varies directly as the load but that the slopes of the curves change with the fuel valve opening.

The curves indicate the the results obtained from fuel valve openings, 2 and 3 on

test 4, were not satisfactory. This was due to weak batteries as shown by tests and it was also noticeable at times that one of the cylinders missed.

The curves on page 34 are constant horsepower and economy lines. The intersection of the dotted and full lines show the most economical spark and fuel valve opening for any desired horsepower. The maximum horsepower obtained was 22.5 with an economy of .77 lbs. of gasoline per B. H. P. hour, of 15000 B. T. U. per B. H. P. hour, and a thermal efficiency of 16.8 %; the fuel valve was wide open and the spark about 45° E.

The calorific value of the gasoline was taken as 19500 B. T. U. per pound, according to Standard Oil Co's tests, and since the work is all comparative the exact value is not needed. The specific gravity of the gasoline was 0.646. Fuel valve openings I, II, and III on the log sheets corresponds to numbers 5/8,

2 and 3-3/8 on a wooden gauge used in the laboratory.

Indicator cards for all of the tests could not be obtained owing to the difficulty in getting the image and in developing the plates. Pages 35 to 43 show cards for some of the tests. Cards marked #1 - #5, #5 - #4 and #3 - #5 weretaken when the engine was run on spark setting #5 and fuel valve opening #2 the other numbers referring to the cylinders 1, 4 and 3.

Card #1 - 5 has a peculiar loop at its exhaust end which is probably due to a momentary back pressure or to a second explosion of the unburned gases remaining in the exhaust chambers. The exhaust valve for cylinder #1 opens 32° early and a momentary back pressure at that instant may have increased the pressure so that the hot exhaust gases ignited to unburned gases. The cards for cylinders 3 and 4 have the same rise at the

exhaust end. Card #5 - #4 shows a very late maximum pressure due to slow ignition of the gas.

The igniter card taken on spark #7 from cylinder #2 indicates that there was a dilute mixture in the cylinder and that the explosion took place near the end of the stroke, although the setting of the spark was 22° early. In other respects the card was good. The card taken from cylinder #4 also represents a poor mixture which ignited very late. The drop in pressure probably means that part of the compression was lost through leakage.

Card #8 - #1 is a fair sample of gas engine indicator card. The sloping explosion line shows a dilute mixture in the cylinder. A second card taken on spark #8 is on page 41. It was taken from cylinder #4 and shows the effect of using only two storage cells while three had been used previously to supply the required current and voltage.

The result was that the cylinder did less work since all the gases did not ignite, some escaping unburned.

When the suction in the carburetor is more than five or six inches, the cylinders do not get a full charge due to high vacuum in the cylinder. This fact is shown by the cards on page 42. Both cards were taken from the same cylinder, but #3 was taken when the suction was four inches of water, while #2 had seven inches. The higher explosion came from #3 and it also shows that the cylinders received a fuller charge, which fact agrees with theory.

Harry G. Dekker
Frank H Mayer

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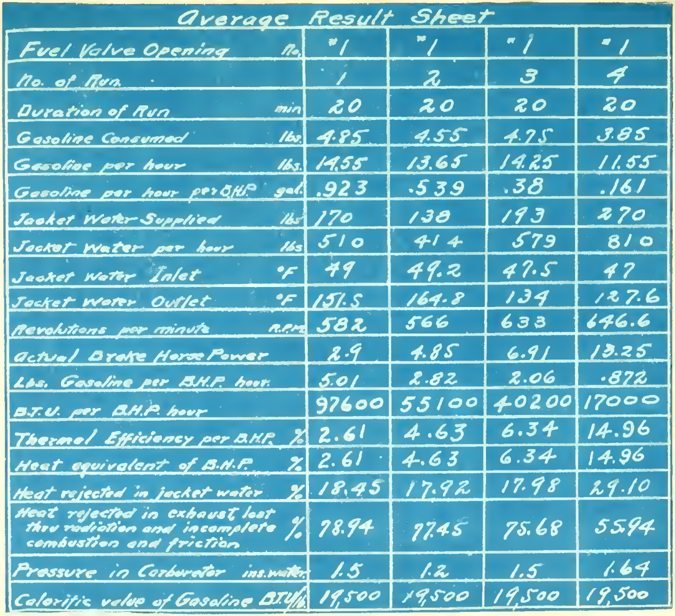

Average Result Sheet

Fuel Valve Opening	No.	#1	#1	#1	#1
No. of Run		1	2	3	4
Duration of Run	min	20	20	20	20
Gasoline Consumed	lbs.	4.85	4.55	4.75	3.85
Gasoline per hour	lbs.	14.55	13.65	14.25	11.55
Gasoline per hour per B.H.P.	gal.	.923	.539	.38	.161
Jacket Water Supplied	lbs.	170	138	193	270
Jacket Water per hour	lbs.	510	414	579	810
Jacket Water Inlet	°F	49	49.2	47.5	47
Jacket Water Outlet	°F	151.5	164.8	134	127.6
Revolutions per minute	R.P.M.	582	566	633	646.6
Actual Brake Horse Power		2.9	4.85	6.91	13.25
Lbs. Gasoline per B.H.P. hour		5.01	2.82	2.06	.872
B.T.U. per B.H.P. hour		97600	55100	40200	17000
Thermal Efficiency per B.H.P.	%	2.61	4.63	6.34	14.96
Heat equivalent of B.H.P.	%	2.61	4.63	6.34	14.96
Heat rejected in jacket water	%	18.45	17.92	17.98	29.10
Heat rejected in exhaust, lost thru radiation and incomplete combustion and friction	%	78.94	77.45	75.68	55.94
Pressure in Carburetor	ins. water	1.5	1.2	1.5	1.64
Calorific value of Gasoline	B.T.U./lb.	19,500	19,500	19,500	19,500

FIG. 9

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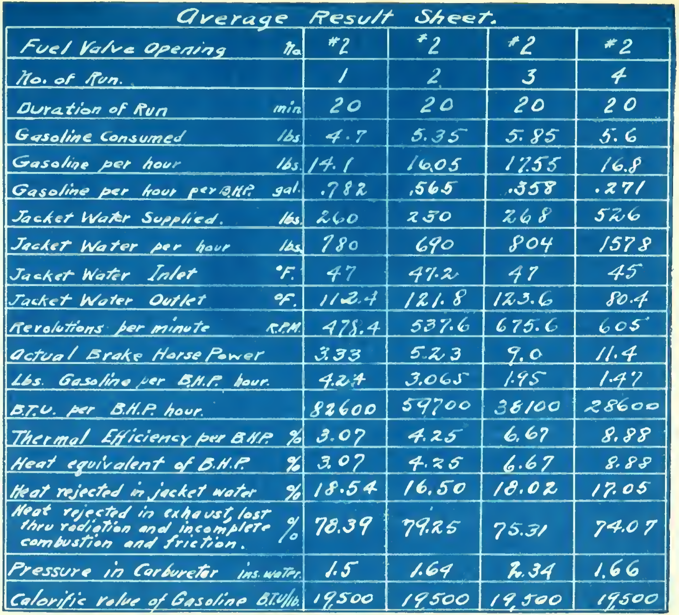
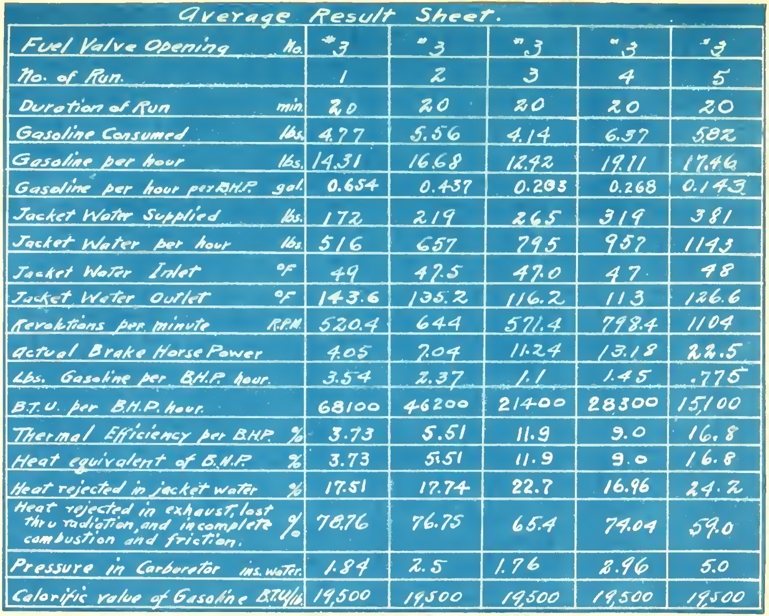


Average Result Sheet.

Fuel Valve Opening	No.	#2	#2	#2	#2
No. of Run.		1	2	3	4
Duration of Run	min.	20	20	20	20
Gasoline Consumed	lbs.	4.7	5.35	5.85	5.6
Gasoline per hour	lbs.	14.1	16.05	17.55	16.8
Gasoline per hour per B.H.P.	gal.	.782	.565	.358	.271
Jacket Water Supplied.	lbs.	260	250	268	526
Jacket Water per hour	lbs.	780	690	804	1578
Jacket Water Inlet	°F.	47	47.2	47	45
Jacket Water Outlet	°F.	112.4	121.8	123.6	80.4
Revolutions per minute	R.P.M.	478.4	537.6	675.6	605
Actual Brake Horse Power		3.33	5.23	9.0	11.4
Lbs. Gasoline per B.H.P. hour.		4.24	3.065	1.95	1.47
B.T.U. per B.H.P. hour.		82600	59700	38100	28600
Thermal Efficiency per B.H.P.	%	3.07	4.25	6.67	8.88
Heat equivalent of B.H.P.	%	3.07	4.25	6.67	8.88
Heat rejected in jacket water	%	18.54	16.50	18.02	17.05
Heat rejected in exhaust, lost thru radiation and incomplete combustion and friction.	%	78.39	79.25	75.31	74.07
Pressure in Carburetor	ins. water.	1.5	1.64	2.34	1.66
Calorific value of Gasoline	B.T.U./lb.	19500	19500	19,500	19500

FIG. 10.



Average Result Sheet.

Fuel Valve Opening No.	#3	"3	"3	"3	"3
No. of Run.	1	2	3	4	5
Duration of Run min.	20	20	20	20	20
Gasoline Consumed lbs.	4.77	5.56	4.14	6.37	5.82
Gasoline per hour lbs.	14.31	16.68	12.42	19.11	17.46
Gasoline per hour per B.H.P. gal.	0.654	0.437	0.203	0.268	0.143
Jacket Water Supplied lbs.	172	219	265	319	381
Jacket Water per hour lbs.	516	657	795	957	1143
Jacket Water Inlet °F	49	47.5	47.0	47	48
Jacket Water Outlet °F	143.6	135.2	116.2	113	126.6
Revolutions per minute R.P.M.	520.4	644	571.4	798.4	1104
Actual Brake Horse Power	4.05	7.04	11.24	13.18	22.5
Lbs. Gasoline per B.H.P. hour.	3.54	2.37	1.1	1.45	.775
B.T.U. per B.H.P. hour.	68100	46200	21400	28300	15,100
Thermal Efficiency per B.H.P. %	3.73	5.51	11.9	9.0	16.8
Heat equivalent of B.H.P. %	3.73	5.51	11.9	9.0	16.8
Heat rejected in jacket water %	17.51	17.74	22.7	16.96	24.2
Heat rejected in exhaust, lost thru radiation, and incomplete combustion and friction. %	78.76	76.75	65.4	74.04	59.0
Pressure in Carboretor ins. water.	1.84	2.5	1.76	2.96	5.0
Calorific value of Gasoline B.T.U./lb.	19,500	19,500	19,500	19,500	19,500

FIG. 11

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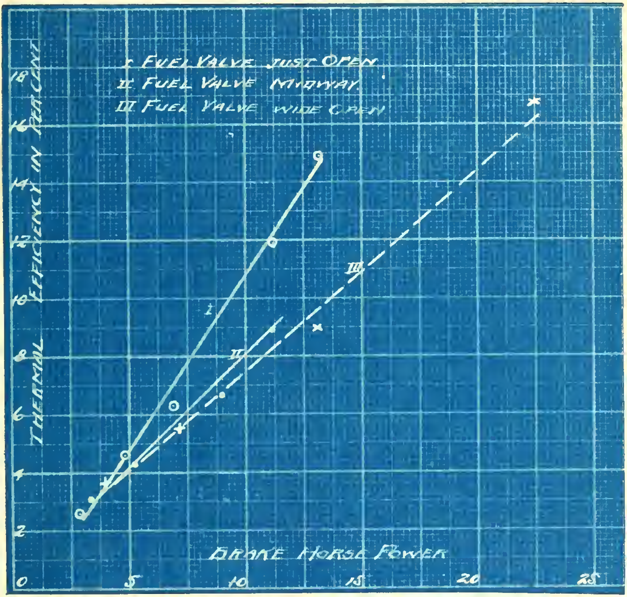
I Fuel Valve just Open.
II Fuel Valve Midway.
III Fuel Valve wide Open.
Thermal Efficiency in Per Cent
Brake Horse Power
I
II
III
0
2
4
6
8
10
12
14
16
18
5
10
15
20
25

FIG. 12.

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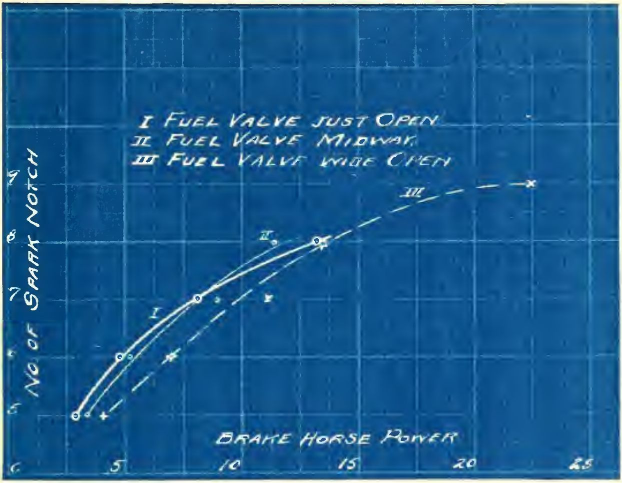

I FUEL VALVE JUST OPEN
II FUEL VALVE MIDWAY
III FUEL VALVE WIDE OPEN
No OF SPARK NOTCH
9
8
7
6
5
0
I
II
III
BRAKE HORSE POWER
5
10
15
20
25

FIG. 13.

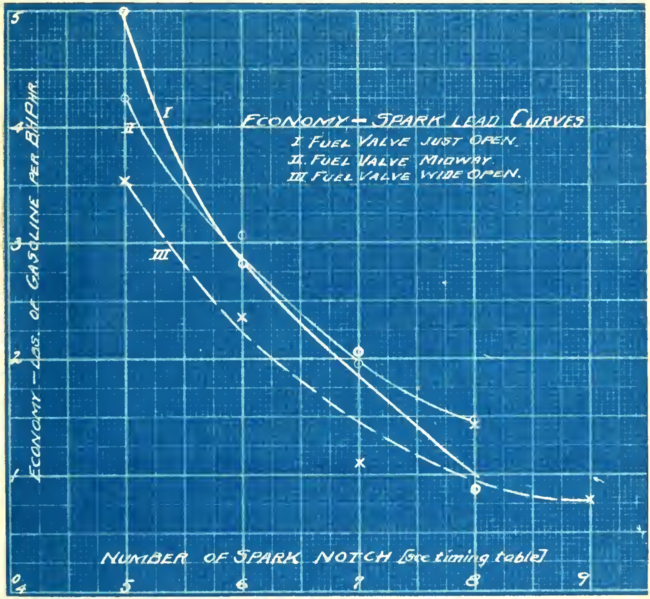
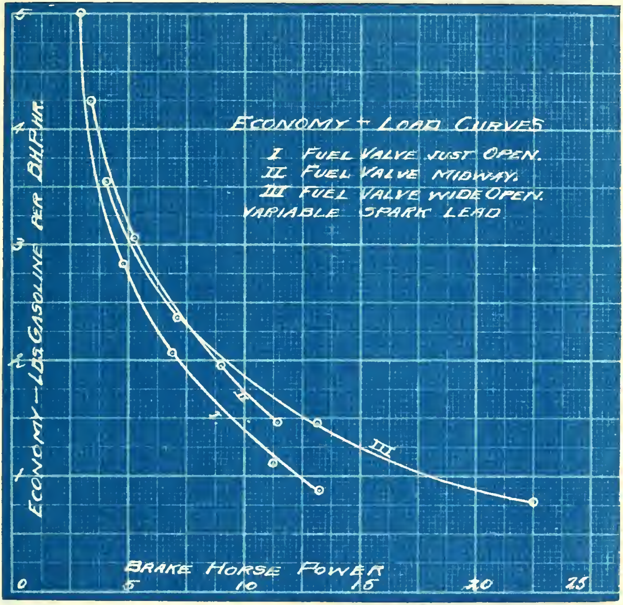

ECONOMY — SPARK LEAD CURVES
I FUEL VALVE JUST OPEN.
II. FUEL VALVE MIDWAY.
III. FUEL VALVE WIDE OPEN.
I
II
III
ECONOMY — LBS. OF GASOLINE PER B.H.P.HR.
5
4
3
2
1
0
NUMBER OF SPARK NOTCH [see timing table]
4
5
6
7
8
9

FIG. 14.



ECONOMY + LOAD CURVES
I FUEL VALVE JUST OPEN.
II FUEL VALVE MIDWAY.
III FUEL VALVE WIDE OPEN.
VARIABLE SPARK LEAD
ECONOMY — LBS GASOLINE PER B.H.P.HR.
BRAKE HORSE POWER
0
5
10
15
20
25
1
2
3
4
5
I
II
III

FIG. 15.

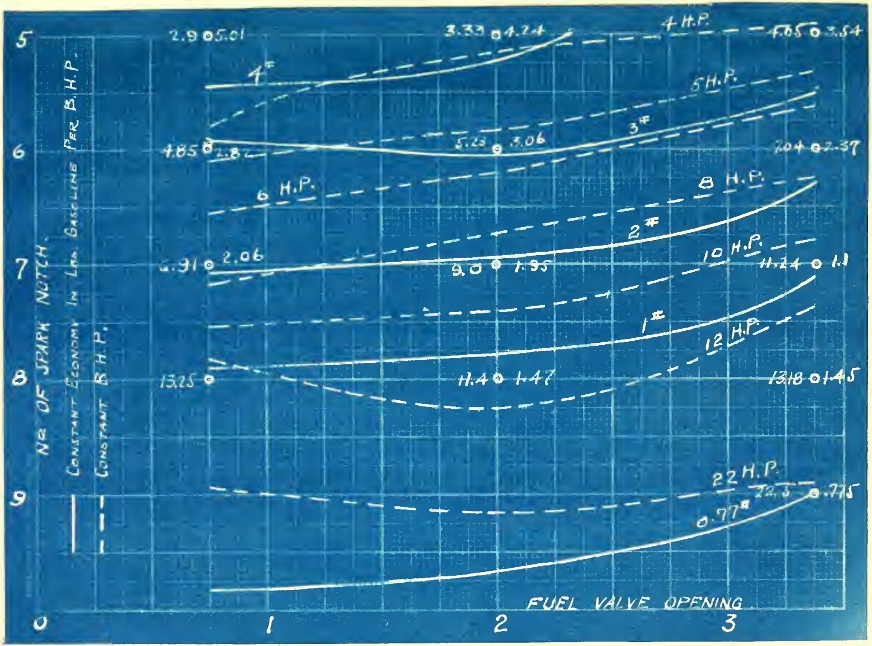
No OF SPARK NOTCH.
CONSTANT ECONOMY IN LBS. GASOLINE PER B.H.P.
CONSTANT B.H.P.
FUEL VALVE OPENING
0
1
2
3
5
6
7
8
9
2.9
5.01
3.33
4.24
4 H.P.
4.65
3.54
4#
5 H.P.
3#
4.85
2.8
5.23
3.06
7.04
2.37
6 H.P.
8 H.P.
2#
6.91
2.06
9.0
1.95
10 H.P.
11.24
1.1
1#
12 H.P.
13.25
11.4
1.47
13.18
1.45
22 H.P.
22.5
.775
0.77#

FIG. 16.

ARMOUR
INSTITUTE OF TECHNOLOGY
[illegible]

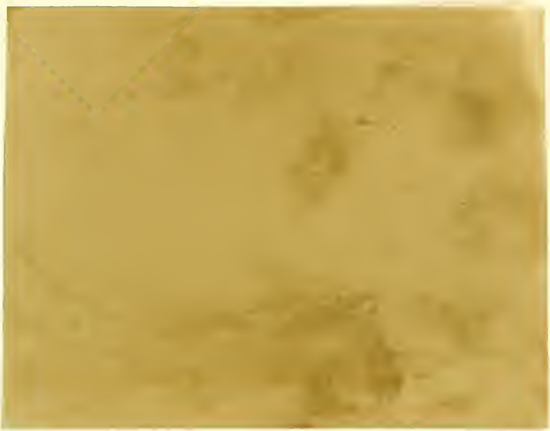


FIG. 17.

INSTITUTE OF TECHNOLOGY
ALABAMA.

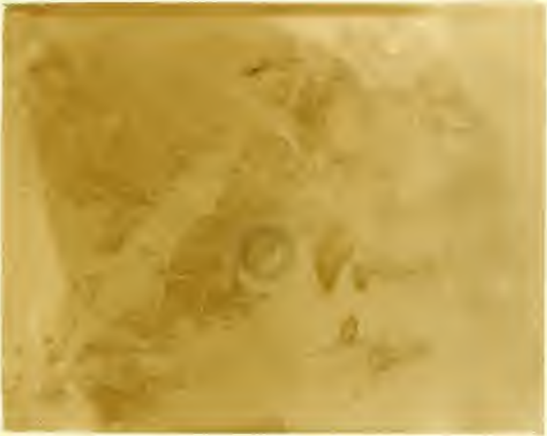


FIG. 13.

ARMOUR
INSTITUTE OF TECHNOLOGY
LIBRARY.

FIG. 13

[illegible]
INSTITUTE OF TECHNOLOGY
[illegible]

FIG. 20

A[illegible]
[illegible]
[illegible]

FIG. 21.

ARMOUR
INSTITUTE OF TECHNOLOGY
LIBRARY

FIG. 22

ARMOUR
INSTITUTE OF TECHNOLOGY
[illegible]

FIG. 23.

ARMOUR
INSTITUTE OF TECHNOLOGY
[illegible]

FIG 24

[illegible]
INSTITUTE OF TECHNOLOGY
ATLANTA.

FIG. 25.

ARMOUR
INSTITUTE OF TECHNOLOGY
LIBRARY

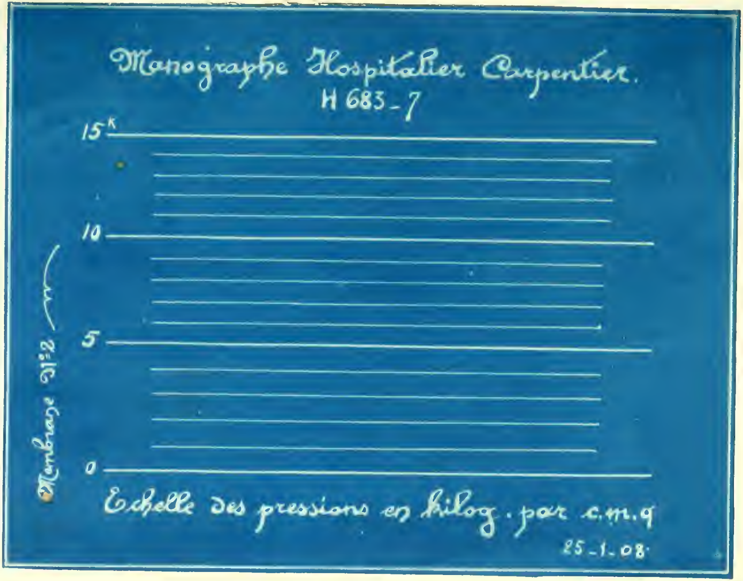
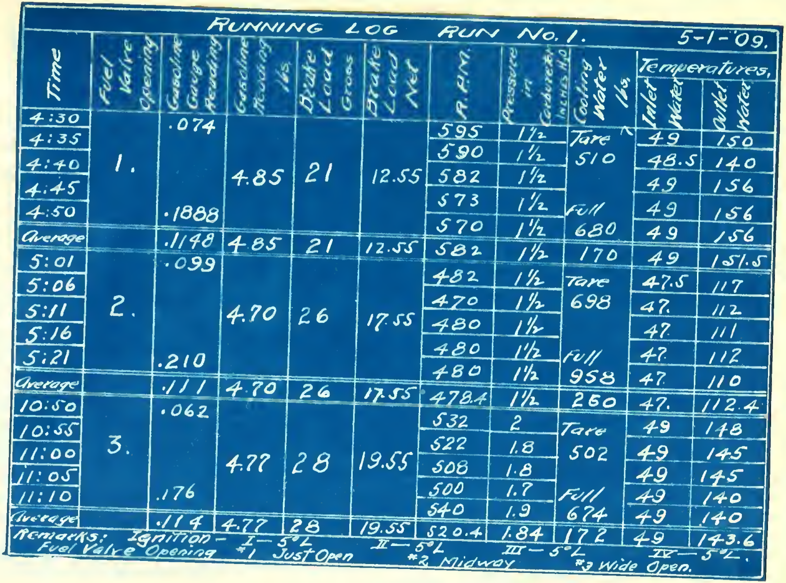

Manographe Hospitalier Carpentier.
H 683_7
15^K
10
5
0
Membrane N°2
Echelle des pressions en kilog. par c.m.q
25_1_08

FIG. 26.

[illegible]
[illegible] TECHNOLOGY
[illegible]



RUNNING LOG RUN No. 1. 5-1-'09.

Time	Fuel Valve Opening	Gasoline Gauge Reading	Gasoline Reading lbs.	Brake Load Gross	Brake Load Net	R.P.M.	Pressure in Carburetor Inches H_2O	Cooling Water lbs.	Temperatures,	
									Inlet Water	Outlet Water
4:30	1.	.074	4.85	21	12.55	595	1½	Tare	49	150
4:35						590	1½	510	48.5	140
4:40						582	1½		49	156
4:45						573	1½	Full	49	156
4:50		.1888				570	1½	680	49	156
Average		.1148	4.85	21	12.55	582	1½	170	49	151.5
5:01	2.	.099	4.70	26	17.55	482	1½	Tare	47.5	117
5:06						470	1½	698	47.	112
5:11						480	1½		47.	111
5:16						480	1½	Full	47.	112
5:21		.210				480	1½	958	47.	110
Average		.111	4.70	26	17.55	478.4	1½	260	47.	112.4
10:50	3.	.062	4.77	28	19.55	532	2	Tare	49	148
10:55						522	1.8	502	49	145
11:00						508	1.8		49	145
11:05						500	1.7	Full	49	140
11:10		.176				540	1.9	674	49	140
Average		.114	4.77	28	19.55	520.4	1.84	172	49	143.6

Remarks: Ignition— I — 5°L II — 5°L III — 5°L IV — 5°L.
Fuel Valve Opening #1 Just Open #2 Midway #3 Wide Open.

FIG. 27.

ARMOUR
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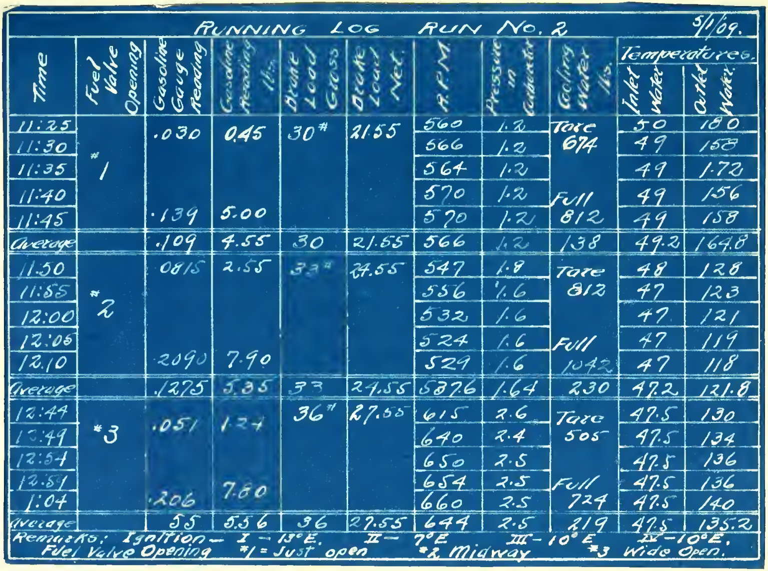
LIBRARY.



RUNNING LOG RUN No. 2 5/1/09.

Time	Fuel Valve Opening	Gasoline Gauge Reading	Gasoline Reading lbs.	Brake Load Gross	Brake Load Net	R.P.M.	Pressure in Carburetor	Cooling Water lbs.	Temperatures.	
									Inlet Water	Outlet Water.
11:25	#1	.030	0.45	30#	21.55	560	1.2	Tare 674	50	180
11:30						566	1.2		49	158
11:35						564	1.2		49	1.72
11:40						570	1.2	Full 812	49	156
11:45		.139	5.00			570	1.2		49	158
Average		.109	4.55	30	21.55	566	1.2	138	49.2	164.8
11:50	*2	.0815	2.55	33#	24.55	547	1.8	Tare 812	48	128
11:55						556	1.6		47	123
12:00						532	1.6		47	121
12:05						524	1.6	Full 1042	47	119
12.10		.2090	7.90			529	1.6		47	118
Average		.1275	5.35	33	24.55	537.6	1.64	230	47.2	121.8
12:44	*3	.051	1.24	36"	27.55	615	2.6	Tare 505	47.5	130
12:49						640	2.4		47.5	134
12:54						650	2.5		47.5	136
12:59						654	2.5	Full 724	47.5	136
1:04		.206	7.80			660	2.5		47.5	140
Average		55	5.56	36	27.55	644	2.5	219	47.5	135.2

Remarks: Ignition — I – 13° E. II – 7° E III – 10° E IV – 10° E.
Fuel Valve Opening *1 = Just open *2 Midway *3 Wide Open.

FIG. 28

LIBRARY
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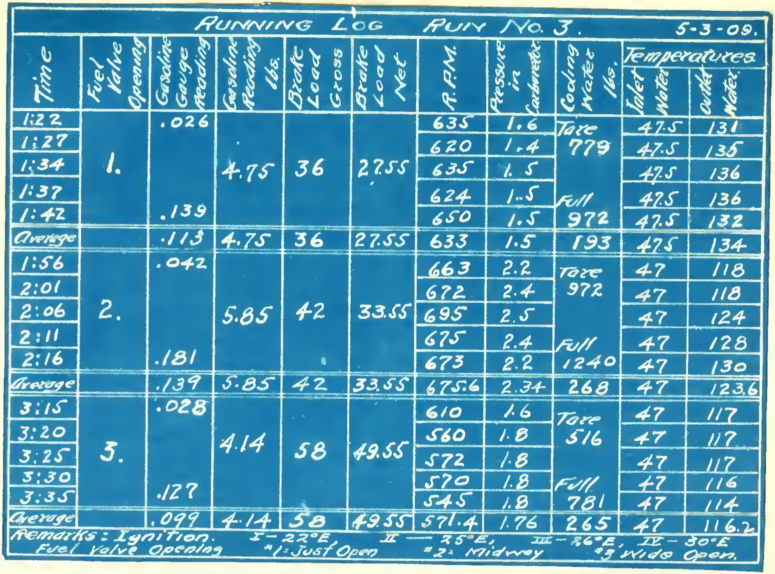
[illegible]



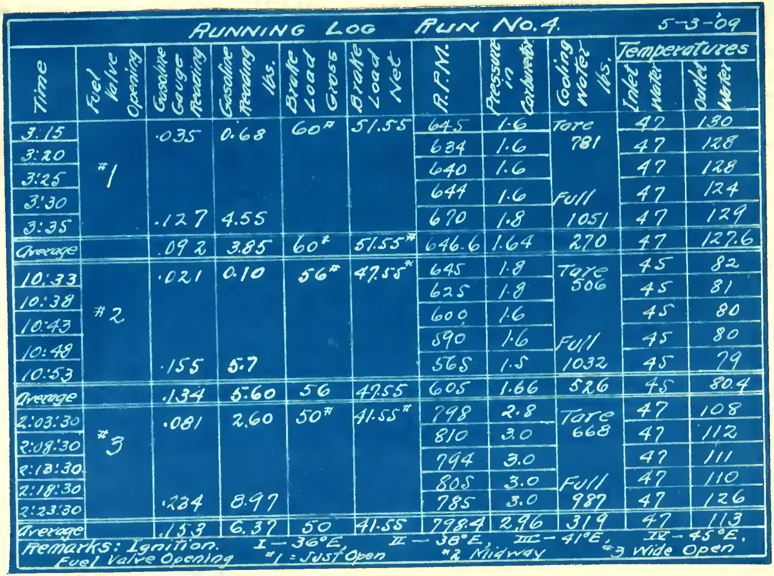
RUNNING LOG RUN No. 3. 5-3-09.

Time	Fuel Valve Opening	Gasoline Gauge Reading	Gasoline Reading lbs.	Brake Load Gross	Brake Load Net	R.P.M.	Pressure in Carburetor	Cooling Water lbs.	Temperatures	
									Inlet Water	Outlet Water
1:22	1.	.026	4.75	36	27.55	635	1.6	Tare 779	47.5	131
1:27						620	1.4		47.5	135
1:34						635	1.5		47.5	136
1:37						624	1.5	Full 972	47.5	136
1:42		.139				650	1.5		47.5	132
Average		.113	4.75	36	27.55	633	1.5	193	47.5	134
1:56	2.	.042	5.85	42	33.55	663	2.2	Tare 972	47	118
2:01						672	2.4		47	118
2:06						695	2.5		47	124
2:11						675	2.4	Full 1240	47	128
2:16		.181				673	2.2		47	130
Average		.139	5.85	42	33.55	675.6	2.34	268	47	123.6
3:15	3.	.028	4.14	58	49.55	610	1.6	Tare 516	47	117
3:20						560	1.8		47	117
3:25						572	1.8		47	117
3:30						570	1.8	Full 781	47	116
3:35		.127				545	1.8		47	114
Average		.099	4.14	58	49.55	571.4	1.76	265	47	116.2

Remarks: Ignition. I – 22°E, II — 25°E, III – 26°E, IV – 30°E
Fuel Valve Opening *1 = Just Open *2 = Midway *3 Wide Open.

FIG. 29.

[illegible]
INSTITUTE OF TECHNOLOGY
[illegible]

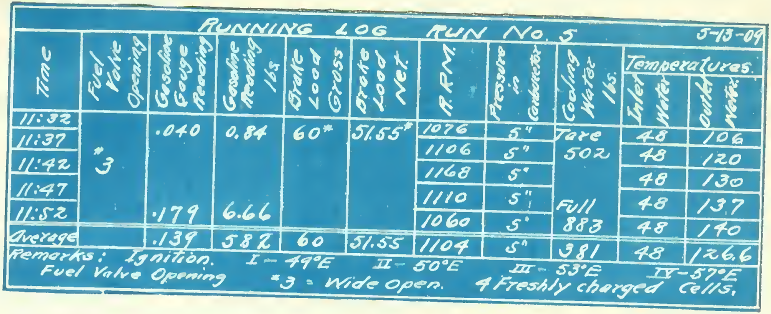


RUNNING LOG RUN No. 4. 5-3-'09

Time	Fuel Valve Opening	Gasoline Gauge Reading	Gasoline Reading lbs.	Brake Load Gross	Brake Load Net	R.P.M.	Pressure in Carburetor	Cooling Water lbs.	Temperatures	
									Inlet Water	Outlet Water
3:15	#1	.035	0.68	60#	51.55	645	1.6	Tare	47	130
3:20						634	1.6	781	47	128
3:25						640	1.6		47	128
3:30						644	1.6	Full	47	124
3:35		.127	4.55			670	1.8	1051	47	129
Average		.092	3.85	60#	51.55#	646.6	1.64	270	47	127.6
10:33	#2	.021	0.10	56#	47.55#	645	1.8	Tare	45	82
10:38						625	1.8	506	45	81
10:43						600	1.6		45	80
10:48						590	1.6	Full	45	80
10:53		.155	5.7			565	1.5	1032	45	79
Average		.134	5.60	56	47.55	605	1.66	526	45	80.4
2:03:30	#3	.081	2.60	50#	41.55#	798	2.8	Tare	47	108
2:08:30						810	3.0	668	47	112
2:13:30						794	3.0		47	111
2:18:30						805	3.0	Full	47	110
2:23:30		.234	8.97			785	3.0	987	47	126
Average		.153	6.37	50	41.55	798.4	2.96	319	47	113

Remarks: Ignition. I — 36°E, II — 38°E, III — 41°E, IV — 45°E.
Fuel Valve Opening #1 = Just Open #2 Midway #3 Wide Open

FIG. 30



RUNNING LOG RUN No. 5 5-13-09

Time	Fuel Valve Opening	Gasoline Gauge Reading	Gasoline Reading lbs.	Brake Load Gross	Brake Load Net	R.P.M.	Pressure in Carburetor	Cooling Water lbs.	Temperatures.	
									Inlet Water	Outlet Water.
11:32	*3	.040	0.84	60*	51.55*	1076	5"	Tare	48	106
11:37						1106	5"	502	48	120
11:42						1168	5"		48	130
11:47						1110	5"	Full	48	137
11:52		.179	6.66			1060	5"	883	48	140
Average		.139	5.82	60	51.55	1104	5"	381	48	126.6

Remarks: Ignition. I – 49°E II – 50°E III – 53°E IV – 57°E
Fuel Valve Opening *3 = Wide Open. 4 Freshly charged Cells.

FIG. 31

[illegible]
[illegible] ECHNOLOGY
[illegible]

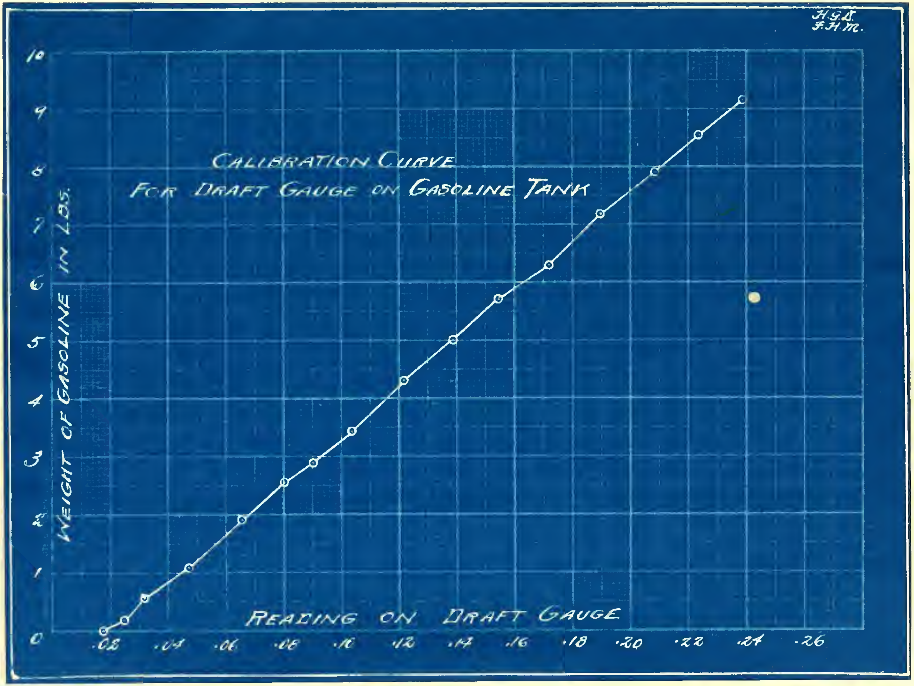
H.G.D.
F.H.M.
Calibration Curve
For Draft Gauge on Gasoline Tank
Weight of Gasoline in Lbs.
Reading on Draft Gauge
10
9
8
7
6
5
4
3
2
1
0
.02
.04
.06
.08
.10
.12
.14
.16
.18
.20
.22
.24
.26

FIG 32

ARMOUR
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LIBRARY